DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, D.C. 20314-1000

ETL 1110-2-311

CEEC-EE

Engineer Technical
Letter No. 1110-2-311

29 February 1988

Engineering and Design
FIRE PROTECTION--HYDROELECTRIC POWER PLANTS

1. Purpose. The purpose of this letter is to provide guidance for the upgrading of fire prevention, fire detection, fire protection and smoke control systems in existing power plants. Means of emergency access and egress from the power plant, and the use of fire resisting materials when modifying or installing new equipment or material in the power plant is also addressed.

2. Applicability. This letter applies to all HQUSACE/OCE elements and field operating activities having responsibility for Civil Works hydroelectric power plant projects.

3. References.

a. EM 1110-2-4205

b. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

c. American Society for Testing and Materials (ASTM)

d. Institute of Electrical and Electronics Engineers (IEEE)

e. Industrial Risk Insurers (IRI)

f. National Fire Protection Association (NFPA)

g. National Electrical Code (NEC)

h. National Electrical Manufacturers Association (NEMA)

i. Occupational Safety and Health Administration (OSHA)

j. Underwriters Laboratories Inc. (UL)

4. Discussion. Typical hydroelectric powerhouse construction is of reinforced concrete and masonry type construction, therefore fire suppression for powerhouses has historically been limited to

This ETL supersedes ETL 1110-2-245, 25 May 1979 fire hoses and fire extinguishers for protection of the structure. Special fire protection systems, such as carbon dioxide (CO_2) systems, have been used to protect generators, equipment within oil storage, purification, and flammable storage rooms. Water deluge systems, installed for large power transformers, have been used to prevent the spread of fire and to protect the adjacent structure. Fire detection systems and smoke control systems have normally not been installed. Existing codes, NFPA, NEC, OSHA, NEMA and Army Regulations, contain many regulations and requirements for fire protection; however, not all are applicable to or required for hydroelectric power plants.

5. Fire Hazard. Fire hazards in a power plant are limited. Power plant structures are of fire resistant or fireproof construction with limited amounts of burnable furniture and decorations. Except for improperly stored combustible materials, and oil flammable liquids, the power plant contains a limited amount of combustible material. Some of the cable insulation for power and control cables installed in the Corps older plants may not be of a material type which will prevent flame propagation; however, all cable runs are provided with short circuit and overload protection which reduces the probability of a fire originating within the cable systems when the protective systems and cables are properly inspected and maintained. In addition, these cable systems are located in areas not normally occupied (cable galleries, cable spreading areas, etc.); hence, do not present a threat to life safety. In the event of a cable fire within these areas, dense and possible toxic smoke may be emitted making the smoke or gases from these fires extremely hazardous if allowed to penetrate into occupied areas or if someone enters the area. In the past, smoke control to evacuate smoke and toxic gases from the powerhouse and fire barriers to prevent the propagation of fire at cable penetrations through walls and ceilings were not always provided.

6. Fire Protection Surveys. A fire protection survey should be performed at existing powerhouses prior to upgrading any of the fire protection equipment. The survey should address life safety, the probability of a fire occurring, specific hazards located at the powerhouse and the probable effect of complete loss of power facilities on reservoir releases. While a project may be able to survive for various amounts of time without significant power production, discharges for regulating river flow and flood control may be critical. The effects of prolonged

discharges through outlet works and spillways during summer and winter should be considered. Recommendations should be presented for an integrated system of fire prevention through the elimination or isolation of the specific hazard, fire suppression for those hazards that cannot be eliminated or isolated, fire detection, emergency access and egress and smoke control. The survey should address and treat occupied and unoccupied areas separately.

7. Elimination of Fire Hazards. Recent surveys made of several power plants, prior to initiating design of the fire protection system, have revealed that combustible materials were improperly stored in areas not designed for such storage. Each power plant should be surveyed on a regular basis and all combustible material, or material capable of supporting combustion found to be improperly stored, should be removed and relocated to storage areas or storage buildings set aside for that purpose.

8. Fire Suppression. Many types of fire suppression or extinguishing systems are available. Water spray provides cooling action, CO_2 reduces the oxygen concentration, isolation removes the fuel from the fire, and halon and dry chemicals disrupt the unrestrained chemical chain reaction needed for combustion. However, not all extinguishing agents are equally effective and cost efficient in certain types of fires. Water used on electrical control equipment and terminal cabinets can cause damage by shorting. CO_2 is not cost effective in large volume areas and the area is not immediately habitable after application. Gas extinguishment (halon) is not effective for deep seated fires. Another factor to consider is whether the suppression system should be activated by automatic or manual means. The consequences of a false trip of an automatic system can be as bad as a fire in that operations personnel may deactivate the system to preclude further trips. After evaluating the hazard and its consequences, the most appropriate suppression system will need to be decided. Many times the amount of fuel can be limited so that no suppression at all is needed and the consequences of having the fire burn itself out can be tolerated.

a. CO_2 Systems. CO_2 systems should be utilized for large generators and motors with closed air circulation systems, oil storage and purification rooms, and paint and flammable liquid storage rooms in accordance with EM 1110-2-4205.

b. Water Systems. Water deluge systems should be provided for outdoor transformers, when the transformers are installed on or adjacent to the structure to help prevent the spread of fire and to limit damage to the structure and other close by transformers and equipment (see EM 1110-2-4205). Fire hose stations and fixed spray systems are not recommended but may be provided in extreme cases for oil filled pipe cable, cable galleries or tunnels, and spreading rooms, along with other areas identified during the fire survey, when it has been established by a fire risk analysis that a threat to life safety exists and the hazard is sufficient to justify the cost. Hose spray nozzles should be of the fog-type which cannot be adjusted to a straight stream and shall be UL rated for use on electrical fires. Automatic systems when installed in unattended powerhouses should deactivate after a specified period of time, and then be capable of automatically reactivating should the fire not be fully suppressed. Disposing of water emitted by these systems is a major consideration and expense, and methods of disposing of the water must be provided.

c. Halon Systems. Automatic halon systems should be limited to computer rooms, small control rooms, and record storage areas. Large control rooms should be protected by installing automatic halon systems directly in the control cabinets and providing hand held halon fire extinguishers. Total flooding may be warranted in smaller rooms. If total flooding is used, all room openings must be sealed, dampers closed and fans shut down automatically. A visible and audible alarm should be activated prior to the halon discharge. Halon systems should not be provided for switchgear rooms.

d. Portable Fire Extinguishers. Portable hand held CO_2 or halon fire extinguishers should be provided and located throughout the powerhouse in accordance with the NFPA. The use of dry chemical fire extinguishers is not recommended, primarily due to cleanup problems.

9. Fire Detection. Automatic fire detectors for detecting the presence of fire, and the initiation of appropriate action, shall be designed and installed in compliance with NFPA 72E. Detectors should be zoned. An alarm from any detector should send a signal

to the local control room and there should be an established procedure for the plant operator upon receipt of the signal. In the case of remote plants, consideration should be given to sending the signal to a master plant or to the fire department. The type of detector to be used should be selected with care as its usefulness will depend on the detector design, the location and environment in which it will be installed, and how well it is maintained. Do not sacrifice reliability for earliest detection. A detector that false alarms is almost as useless as a detector that does not alarm. The detector location is also important as detectors are relatively insensitive in stagnant or zero air flow conditions. Detectors for high air flow conditions, such as in air ducts, require special type construction.

a. Ionization Detectors. Smoke detectors, utilizing the ionization principles, are usually of the spot type containing a small amount of radioactive material for ionizing the air in the sensing chamber, thus making the air conductive. When combustion products enter the ionization area they decrease the conductance of the air, thus reducing the amount of current flow across the sensing chamber. When the conductance is less than a predetermined level the detector responds. Ionization detectors react to both visible and invisible particles of the first stages of a fire. As a class, ionization detectors provide a somewhat faster response to high energy (open flaming) fires, since these fires produce more of the smaller smoke particles. Some plastics such as polyvinyl chloride (PVC) insulation when heated, as by an overload, generate a dense opaque smoke cloud composed of many gases including chlorine and hydrogen-chloride. These gases are highly toxic and corrosive and can be detected by an ionization detector but because of the larger smoke particles, the ionization detectors may not yield the fastest response.

b. Photoelectric Detectors. Photoelectric detectors use a light source and a photosensitive device mounted in a light-proof chamber. The two main types of photoelectric detectors are the photoelectric light obscuration type and the photoelectric light scattering type. In the photoelectric light obscuration type, smoke particles between the light source and the photosensitive device reduce the light reaching the device, causing the detector to operate. In the photoelectric light scattering type, light rays do not normally fall onto the photosensitive device. Smoke particles enter the light path, light strikes the particles and is scattered onto the photosensitive device, causing the detector to operate. As a class, photoelectric smoke detectors respond faster to the smoke generated by low energy (smoldering) fires, as these fires produce more of the larger smoke particles.

c. Heat Sensing Detectors. Heat sensing detectors are of two general types, both of which respond to abnormal heat conditions. The fixed temperature type operates when its operating element becomes heated to a predetermined level. The rate-of-rise type operates when the temperature rises at a rate exceeding a predetermined amount. A detector which is a combination of the two types is also available.

d. Other Types. Detectors available for specialized purposes are infrared detectors which react to heat radiation; pressure detectors which react to shock of an explosion; ultraviolet detectors which react to radiation given off by arcs and fires and heat-sensitive cable in which detection is continuous along a path.

e. Conclusions.

(1) Heat sensing detectors are best suited for locations within equipment, such as generators or near flammable fluids.

(2) Ionization detectors are best suited for high energy, open flaming fires. Location near arc-producing equipment should be avoided.

(3) Photoelectric detectors are best suited for low energy, smoldering fires.

(4) The combined use of photoelectric detectors with ionization detectors along a cable tray installation should provide earliest detection.

(5) Heat-sensitive cable installed in each cable tray, and designed to annunciate by zones and tray location, are best suited for quickly determining the location of the probable fire.

(6) Location of detectors in a pattern or the close

spacing of detectors, as some codes recommend for general room protection, is not necessary. Detectors should be located at or near the probable fire source, such as near cable trays, or in the path of heating and ventilating air movement.

10. Isolation and Smoke Control. Isolation of fire and smoke is a significant fire control item. Smoke inhalation is one of the major causes for loss of life in any fire situation. Toxic fumes from a small fire could require total evacuation of the powerhouse. Existing ventilating systems may contribute to spreading smoke throughout the powerhouse.

a. Smoke Control. The primary purpose of smoke control in a building is to evacuate smoke and toxic particles to allow for emergency access and egress. In buildings or chambers with relatively small air volumes, it is sometimes effective to shut down the air flow systems completely and let the fire deplete the oxygen in the air and self-extinguish. However, in most powerhouse facilities, the air spaces are too large and the buildings are not air tight. Sending fire fighters into the structure and supplying 100% outside air is more effective. Areas critical to continued emergency occupancy and protection of exit passageways should be considered. Generally speaking, the HVAC system should be designed to have a smoke control mode that will be activated automatically by smoke detectors. Detection of smoke by the first detector shall cause an alarm signal to be transmitted. Detection of smoke by additional detectors shall automatically activate the Heating, Ventilation and Air Conditioning (HVAC) system in the smoke control mode for that zone. The control room and stairways that are used for emergency access and egress should be pressurized according to ASHRAE recommendations using 100% outside air. Smoke exhaust fans in the generator high bays should be activated and 100% outside air provided to evacuate smoke from the powerhouse. Smoke exhaust fans should be installed according to NFPA and IRI requirements and should have a 500 degree F rating. Dampers, valves and other power operated devices should be configured to provide operation in the smoke control mode in the case of a power outage. A switch on the control panel should be provided for testing the smoke ventilation equipment.

b. Isolation. Isolation through the use of fire and smoke barriers should be considered on a case by case basis. Care should be taken to not seal openings which are required for plant ventilation systems. Where cable trays pass through a floor or wall which is considered a fire wall, and where cables leave the tray and enter the switchgear or a switchboard through a slot, a fire-stop should be provided. Fire-stop material should provide both a fire barrier and a smoke barrier and the method selected should allow for future removal and/or addition of cables. Fire-stop material should be specified in terms of hour rating and testing according to ASTM E-119. Single conduit or single cables which penetrate a fire wall can be sealed with special fittings made by several manufactures. Thick seals should be avoided as they could contribute to excessive cable insulation operating temperature.

11. Emergency Access and Egress. Emergency access and egress from each area must be evaluated to assure that suitable escape routes exist and that access is provided for fire suppression or rescue. Emergency lighting, exit signs and directions, uncomplicated exit routes, elevator recall and emergency, and self-contained breathing apparatus should be provided.

12. Insulated Electrical Cable. All new wire and cable to be installed in the powerhouse shall conform to the applicable requirements of NEMA WC7 or WC8 and shall in addition be of flame retardant construction. All cable installed in cable trays shall pass IEEE Standard 383 flame test, paragraph 2.5, using the ribbon gas burner. Single conductors installed in conduit and individual conductors of multiple-conductor cables shall pass the flame test of NEMA WC7, paragraph 6.12.5. Polyvinyl chloride (PVC) shall not be used as conductor insulation or as jacket material as the combustion products are extremely toxic. Where the above cable types are installed the fire suppression systems of paragraph 8 are generally adequate. However, most of the cables installed in the Corps older plants are not sufficiently flame retardant.

13. Alarm Monitor. The power plant local annunciation and, if applicable, the remote alarm system should be used to monitor the fire detecting alarms. A local alarm system should be provided for each area. Properly applied, these systems will provide more reliable and useful alarm data than the minimum alarm monitor specified in the fire codes.

14. Recommendations. When designing a "Fire Protection System" for a power plant the following as a minimum is recommended:

a. A fire protection survey should be conducted to determine the specific hazards located in the power plant and the probability of a fire occurring. Locations of the specific hazards should be addressed and the determination made, in accordance with the applicable provisions of NFPA 101, as to whether or not the hazard is a threat to life safety in normally occupied areas. Where possible, the specific hazard should be eliminated or isolated.

b. Automatic fire detectors should be designed and installed in the power plant in accordance with NFPA 72E. Detectors should be zoned and annunciated by zones. Careful consideration should also be given to the location and type of detectors specified.

c. A means of isolation of possible fire and smoke in the power plant should be provided. Ventilation systems should be designed or modified to evacuate smoke and toxic particles to allow for emergency access and egress. Fire barriers and smoke control barriers should be provided to prevent the transmission of the fire and smoke from one area to another.

d. When replacing or installing new materials, such as power and control cables, fire resisting material should be specified.

e. Fire suppression systems should be specified when it has been determined that the specific hazard cannot be eliminated. CO_2 systems, if not already provided, should be provided for the generator, oil storage and purification rooms, and flammable storage rooms. Water deluge systems, if not already provided, should be provided for large outdoor oil filled transformers when the transformer is located on or adjacent to the structure. Halon systems may be provided for control rooms, computer rooms and record storage rooms. Water suppression systems for oil filled pipe cable, cable galleries or tunnels, and spreading rooms, along with other areas identified during the fire risk analysis are not recommended unless justified in accordance with paragraph 8b above.

f. A survey should be made to determine if a means of emergency access to and egress from the power plant exists. In those instances where sufficient means of access and egress does not exist they should be provided.

FOR THE COMMANDER:

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